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DEVIATION IN DEVELOPMENT DUE TO THE USE OF UNRIPE SEEDS.

By J. C. Arthur.

(*Continued from page 815.*)

Such deviations as have been mentioned are readily seen, and are more or less to be anticipated. But what shall we say about the final recovery of such plants? Even if plants are feeble while young, will they not eventually become firmly established and outgrow all traces of early weakness? I think we would say *a priori*, that such would doubtless be the case. It looks reasonable; and yet from both experimental and theoretical data it can be shown that rarely, and only by accident, does the entire restoration of the vigor of the plant under such circumstances take place. I am aware that the majority of observers and writers have held the contrary view, and that Cohn in his admirable treatise came to the conclusion that "in general plants raised from unripe seed are not weaker than those from ripe seed." It is undoubtedly true, that as the plants grow, the differences, which were at first readily detected by the eye, largely or quite disappear. Eventually it is necessary to resort to careful weighing and measuring to bring out the actual facts. This does not mean that the differences are slight and immaterial, but only that the eye cannot detect small variations distributed throughout large objects having irregular surfaces, although in the aggregate they may be considerable.

In the experiment with tomato plants from seed taken from green, half-ripe, and fully ripe fruit, already referred to, (manuscript record No. 82), no essential difference could be detected between the plants after they came into bearing. But weighing exposed the fact that the ripe fruit of the plants from green seed averaged ten per cent lighter than those from ripe seed (see table V).

V.—TOMATOES FROM RIPE AND UNRIPE SEEDS.

Experiment conducted by Arthur.

Degree of ripeness.	Number of plants.	Number of ripe fruit.	Total weight of fruit in grams.	Average weight of single fruit in grams.
Fruit green.........	13	1044	18304	17.5
Fruit half ripe.....	5	439	7858	17.9
Fruit fully ripe...	24	1889	36622	19.4

The experiment with wheat, conducted by Nowacki, and already referred to (see table III), shows a larger number of stalks from ripe than from green seed; and although not so tall, the total growth of stalks in length is greater for the plants from ripe than from green seed. Without going into further details, the general principle may be stated, that plants from green seed will, as a rule, attain a smaller development in both vegetative and reproductive parts than those from ripe seed.

It is furthermore to be pointed out in this connection, that not only are all parts of the plant smaller and less vigorous, but that the different organs bear a different reciprocal proportion. We may classify plant organs roughly as reproductive (fruit, seed, etc.) and vegetative (leaf, stem and root.) The use of immature seed increases the reproductive parts at the expense of the vegetative, and thus it comes about, that there is more fruit formed in proportion to the amount of foliage than normal. In an experiment, or rather a series of experiments originated by Goff,[30] and continued by the originator and the writer, in which the changes due to the use of unripe seed have been made more than ordinarily prominent by the cumulative effect of repetition through several generations, it was found by the writer (see table VI) that a tomato plant, selected as representative of the series grown from unripe seed, bore 3½ pounds of fruit to one pound of the vine (leaves, stems and roots taken together), while a plant of the same variety grown each year under the same conditions, but always from ripe seed gave only 1⅛ pounds of fruit for each pound of the vine. In this case we have an enormous relative increase of fruitage from unripe seed, which in fact was quite apparent to the casual observer upon looking at the plants of the two series as they grew in the garden, although it required the scales to disclose how surprisingly great the difference really was. With this increased fruitfulness is also associated an increase in the number of fruit, although they are individually smaller, as also are the seeds. It is stated that von Mons,[31] of Belgium, has applied this method of using green seed to the raising of apples, in order to check too vigorous growth and to increase the fruitfulness.

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[30] For history of these experiments, see Bot. Gaz., xii (1887), pp. 41-42; Rep. Wis. Exper. Sta., viii (1891), pp. 152-159.

VI.—TOMATOES FROM RIPE AND UNRIPE SEEDS.

Experiment conducted by Arthur.

Degree of ripeness.	Weight of vine.		Weight of fruit.		Ratio of vine to fruit.
	lb.	*oz.*	*lb.*	*oz.*	
Immature series	2	10	9	2	1 : 3.475 (3½)
Mature series	5	10½	6	9	1 : 1.127 (1⅛)

In connection with the increase of the number of fruit borne by a plant, there is also a tendency to increased earliness in ripening the fruit. In the cumulative trials with tomatoes by Goff, which have just been referred to, the strain from green seed ripened from ten days to four weeks earlier in different years, than the corresponding series from ripe seed. In another experiment with tomatoes by Goff,[32] seed saved from fruit of the same variety, in different stages of maturity, described as very green, pale green, tinged red, light red, deeper red, and fully ripe (see table VII), gave an advantage in earliness of nearly three weeks for the plants from the very green seed compared with those from the fully ripe seed, and of two weeks compared with those from the half ripe seed; and there was also about two-thirds as much gain in the ripening of the first ten fruits upon the same plants respectively. But such marked difference in earliness, or in fact any difference at all, in favor of plants from immature seed does not always occur; and several observers have noted the reverse results.

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[31] Williams, E., Rural New-Yorker, 1890, p. 798.

[32] L. c., iii (1884), p. 224.

VII.—TOMATOES FROM RIPE AND UNRIPE SEEDS.

Experiment conducted by Goff.

Degree of ripeness.	Number of seeds.	Vegetated per cent.	First ripe fruit.	First ten ripe fruit.
Very green	50	2	126 days.	137 days.
Pale green	50	84	143 days.	157 days.
Tinged Red	50	100	140 days.	151 days.
Light red	50	96	141 days.	147 days.
Deeper red	50	88	141 days.	147 days.
Fully ripe	50	96	146 days.	152 days.

This is not surprising in view of the fact that it is the weaker plants from which the greater earliness in fruiting is expected, and such plants must necessarily be most affected by the conditions of weather, soil and cultivation, and so their uniform development be most interfered with. It was noted by Goodale,[33] in 1885, and since by Goff,[34] that some early market varieties of vegetables indicate that they may have been originated through the use of green seed.

I have now stated the principal deviations from normal development in plants due to the use of immature seed, which I have myself observed, or for which I find authentic recorded data. They may be grouped and briefly summarized as follows: (1.) There is a loss of vigor, shown in the smaller percentage of germinations, the weakness of the seedlings, and the greater number of plants which die before maturity; (2) the full vigor of the plants is never recovered, although they may and usually do, produce an abundant harvest, and one acceptable to the cultivator, in case of economic plants; (3) the re-

[33] Physiological Botany, 1885, p. 460.

[34] Bot. Gazette, xii (1887), p. 41.

productive parts of the plants are increased in proportion to the vegetative parts, resulting in a greater number of fruits and seeds (although individually smaller) and more rapid ripening of them, than in similar plants from mature seed.

In explanation of these changes, and to bring the phenomena into proper relation with other phenomena of plant and animal life, I venture to assert that *the deviation in development, which comes from the use of unripe seed, does not differ in kind from that resulting from any other method of weakening the organism,* and is to be considered as only a special instance of *the effect of checking the uniform normal growth of the individual.*

I have in my possession a large amount of data with which to substantiate this proposition, but it would be tiresome to present it here, and I shall content myself with a bare reference to a few facts, and trust to your being able to further convince yourselves of its correctness by recalling facts from your own researches or observations.

Imperfect seed of any kind germinates poorly and produces weak plants. This is true of seed shriveled because of injury to the parent plant from insects, fungi, drouth, etc., of seed infested with fungus, of seed that is too old, or of seed deprived of part of its nutriment or otherwise seriously mutilated. That weak seedlings from any cause, as a rule, are likely to remain weak and produce a poor crop, I think is a statement that will be generally accepted without elaboration. It is in reference to the third general feature of the deviations due to immature seed that the chief interest rests; an interest that has sprung up very largely in consequence of the numerous experiments by Professor Goff, extending over the last ten years, and now very widely known, more especially his long series of experiments with tomatoes, in which notable results have been obtained, suggestive of wide economic application, but to which I have been able to make but brief reference in this paper.[35]

[35] Goff's work upon unripe tomato seed and resulting strains is recorded as follows:

Rep. N. Y. Exper. Sta., iii (1884) pp. 224–226; iv (1885), pp. 182–183; v (1886), p. 174.

Bot. Gaz. xii (1887), p. 41–42.

Garden and Forest, iii (1890), p. 427; (see also pages 355 and 392). Cited by Hunn, Bull. N. Y. Exper. Sta. No. 30 (1891), p. 478.

Rep. Wis. Exper. Sta. viii (1891), pp. 152–159.

While the use of immature seed brings about greater activity in reproduction, and a tendency to early maturity, the same is also true of plants from very old seed, as has been recognized for a very long time. It is probably best known in reference to melons,[36] which are generally believed to give more and better fruit when the seeds are five to twenty years old,[37] although the plants will be weak. Observations have not, however, been confined to melons, but are recorded for pears, beans, lentils, etc.

The retardation of the germination due to age is well shown by the tests of tomato seeds made by Lovett,[38] in which seeds from 2 to 6 years old showed the first germination in 10 days, 7 years, in 11 days, 8 and 9 years in 12 days 10 and 11 years, in 14 days, and 13 years, in 18 days. It will be observed that the effect of over-maturity is the same as results from immaturity (cf. table III). The similarity of effect is even better shown by a test of red clover seed made by Nobbe[39] in 1874, in which mature and immature seed of the crop of that year was compared with that of the crop of 1870, the trial being made in December, 1874. The germination of the immature seed was slower than that of the mature seed which had been kept four years, while the total number of germinations for both immature and over-mature seed was much decreased by four years' keeping (see table VIII).

It is evident, therefore, that aging as well as immaturity of seed leads to weakness of the seedlings, and a general lowered vitality.

Some of the same characteristics which we have seen in the plants from immature seed may also be observed when plants

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[36] "Es ist behaupted worden, dass Melonenkerne nach mehrjähriger Aufbewahrung Pflanzen liefern, welche weit weiniger ♂ Blüthen bringen, als Pflanzen aus frischen Samen ; nach 5 Jahren sollten angeblich gar keine ♂ Blüthen gebildet werden. Verf. säete 1878 Melonensamen von 1876 und von 1870. Von den älteren Samen keimte eine geringere Zahl; die daraus hervorgegangenen Pflanzen waren etwas weniger kräftig." Baillon (Bull. mens. soc. Linn. de Paris, No. 23, 1878) Just's Bot. Jahresb. vi (1878), p. 328.

[37] Fleischer, l. c., p. 17; Schulz, quoted by Cohn, Symbola, p. 9.

[38] Rep. N. Y. Exper. Sta., ii (1883), p. 267.

[39] Samenkunde, p. 346.

VIII.—GERMINATION OF RIPE, UNRIPE, AND OLD SEED OF RED CLOVER.

Experiment conducted by Nobbe.

Degree of ripeness.	Per cent of total germination in 2 days.		Total germination.	
	Soon after gathering.	4 years after gathering.	Soon after gathering.	4 years after gathering.
Immature seed.............	63	0	48	6
Mature seed.................	90	24	88	58

grown on good and on poor soil are compared. It has been noticed by tomato growers that more seed is obtained on poor than on rich soil,[40] which accords with the record for immature strains.[41] The difference in fertility of soil need not be especially marked to secure the effect, if other conditions are reasonably uniform, even good soil compared with yet richer soil produces the characteristic results. In some experiments on wheat made by Latta,[42] the yield on good wheat land was one pound of straw to .55 of a pound of grain, but the same land richly fertilized gave one pound of straw to only .48 of a pound of grain (see table IX); that is, the poorer soil brought about a greater development of the reproductive parts of the plants, as compared with the vegetative parts, than did the richer soil, without regard to the mode of fertilization. This phase of the subject might be extended to great length and many statistics given, but it will suffice for illustration to appeal to common observation of the remarkable size of the flowers and seed pods of depauperate weeds and other plants, and on the other hand, the tendency of plants in rich soil to produce foliage shoots rather than fruit.

It has been recognized by zoologists[43] that " checks to nutri-

[40] Allen, Amer. Gard., xi (1890), p. 358.

[41] Goff, Rep. Wis. Exper. Sta., viii (1891), p. 157.

[42] Bull. Ind. Exper. Sta., No. 41 (1892), p. 94.

[43] Geddes and Thompson, Evolution of sex, p. 218.

IX.—Wheat on Poor and Rich Soil.

Experiment conducted by Latta.

Plat unfertilized produced	1 lb. of straw to .56 lbs. of grain.
Plat with {bone black, ammonia, potash,} produced	1 lb. of straw to .45 lbs. of grain.
Plat with {bone black, ammonia, potash,} produced	1 lb. of straw to .47 lbs. of grain.
Plat unfertilized producéd	1 lb. of straw to .55 lbs. of grain.
Plat with horse manure produced	1 lb. of straw to .49 lbs. of grain.
Plat with horse manure produced	1 lb. of straw to .51 lbs of grain.
Plat unfertilized produced	1 lb. of straw to .52 lbs. of grain.
Plats unfertilized averaged	1 lb. of straw to .55 lbs. of grain.
Plats fertilized averaged	1 lb. of straw to .48 lbs. of grain.

tion, especially in the form of sudden scarcity, will favor sexual reproduction." I think I may safely enlarge this statement, and say that *any cause which retards uniform progress in the development of an animal or plant favors reproduction.* By this is meant that after such a check occurs the organism will develop the reproductive parts of its structure faster and more fully than the other parts, and in the case of crops the yield of seed will be greater proportionately, than of the leaves and stems.[44]

Enough has doubtless been said to show that the deviations in development, which arise when unripe seeds are used, drop into a general category of changes dependent upon the available energy of the plant and the uniformity of its development. In general, the change is a tendency toward reproduction at the expense of the vegetative parts of the plant.

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EDITOR'S TABLE.

—The late meeting of the American Association for the Advancement of Science was an occasion of instruction and pleasure to all concerned. The hospitality of the citizens of the beautiful city of Springfield and the generally delightful weather, contributed much to the comfort of the visitors. The excursions to points less remote than usual, were, on this account, more enjoyable. The leading club of the place gave a unique entertainment, furnished by the talent of the members.

The only regrettable feature was the small attendance, less than four hundred members having been present. As the locality was accessible to the most populous region of the country, this absence of many of our best-known cultivators of science excited comment. Such a considerable number of our best zoologists remained away from the meeting that the section of zoology was reduced to a fragment of what it should had been. A considerable number of the geologists failed to attend most of the sessions of their section.